Office of the Secretary Of Defense (OSD)
Deputy Director of Defense Research & Engineering
Deputy Under Secretary Of Defense (Science & Technology)
Small Business Innovation Research (SBIR)
FY2008.3 Program Description

Introduction

The Deputy Under Secretary of Defense (Science & Technology) SBIR Program is sponsoring the Defense Health Program Biomedical Technology theme, the Materials Technology theme, the Energy and Power Technology theme, and the Cognitive Readiness Technology theme in this solicitation.

The Army, Navy, and Air Force are participating in the OSD program this year. The service laboratories act as our OSD Agent in the management and execution of the contracts with small businesses. The service laboratories, often referred to as a DoD Component acting on behalf of the OSD, invite small business firms to submit proposals under this Small Business Innovation Research (SBIR) Program solicitation. In order to participate in the OSD SBIR Program this year, all potential proposers should register on the DoD SBIR Web site as soon as you can, and should follow the instruction for electronic submittal of proposals. It is required that all bidders submit their proposal cover sheet, company commercialization report and their firm's technical and cost proposal form electronically through the DoD SBIR/STTR Proposal Submission Web site at http://www.dodsbir.net/submission. If you experience problems submitting your proposal, call the help desk (toll free) at 1-866-724-7457. You must include a Company Commercialization Report as part of each proposal you submit; however, it does not count against the **proposal page limit of 25 pages**. Please note that improper handling of this form may result in the proposal being substantially delayed. Information provided may have a direct impact on the review of the proposal. The DoD SBIR Proposal Submission Web site allows your company to come in any time (prior to the proposal submission deadline) to edit your Cover Sheets, Technical and Cost Proposal and Company Commercialization Report.

We <u>WILL NOT</u> accept any proposals that are not submitted through the on-line submission site. The submission site does not limit the overall file size for each electronic proposal, there is only a 25 page limit. However, file uploads may take a great deal of time depending on your file size and your internet server connection speed. If you wish to upload a very large file, it is highly recommended that you submit prior to the deadline submittal date, as the last day is heavily trafficked. You are responsible for performing a virus check on each technical proposal file to be uploaded electronically. The detection of a virus on any submission may be cause for the rejection of the proposal. We will not accept e-mail submissions.

Firms with strong research and development capabilities in science or engineering in any of the topic areas described in this section and with the ability to commercialize the results are encouraged to participate. Subject to availability of funds, the DUSD(S&T) SBIR Program will support high quality research and development proposals of innovative concepts to solve the listed defense-related scientific or engineering problems, especially those concepts that also have high potential for commercialization in the private sector. Objectives of the DUSD(S&T) SBIR Program include stimulating technological innovation, strengthening the role of small business in meeting DoD research and development needs, fostering and encouraging participation by minority and disadvantaged persons in technological innovation, and increasing the commercial application of DoD-supported research and development results. The guidelines presented in the solicitation incorporate and exploit the flexibility of the SBA Policy Directive to encourage proposals based on scientific and technical approaches most likely to yield results important to DoD and the private sector.

Description of the OSD SBIR Three Phase Program

Phase I is to determine, insofar as possible, the scientific or technical merit and feasibility of ideas submitted under the SBIR Program and will typically be one half-person year effort over a period not to exceed six months, with a dollar value up to $100,000. We plan to fund 3 Phase I contracts, on average, and downselect to one Phase II contract per topic. This is assuming that the proposals are sufficient in quality to fund this many. Proposals should concentrate on that research and development which will significantly contribute to proving the scientific and technical feasibility of the proposed effort, the successful completion of which is a prerequisite for further DoD support in Phase II. The measure of Phase I success includes technical performance toward the topic objectives and evaluations of the extent to which Phase II results would have the potential to yield a product or process of continuing importance to DoD and the private sector, in accordance with Section 4.3.

Subsequent Phase II awards will be made to firms on the basis of results from the Phase I effort and the scientific and technical merit of the Phase II proposal in addressing the goals and objectives described in the topic. Phase II awards will typically cover 2 to 5 person-years of effort over a period generally not to exceed 24 months (subject to negotiation). Phase II is the principal research and development effort and is expected to produce a well defined deliverable prototype or process. A more comprehensive proposal will be required for Phase II.

Under Phase III, the DoD may award non-SBIR funded follow-on contracts for products or processes, which meet the component mission needs. This solicitation is designed, in part, to encourage the conversion of federally sponsored research and development innovation into private sector applications. The small business is expected to use non-federal capital to pursue private sector applications of the research and development.

This solicitation is for Phase I proposals only. Any proposal submitted under prior SBIR solicitations will not be considered under this solicitation; however, offerors who were not awarded a contract in response to a particular topic under prior SBIR solicitations are free to update or modify and submit the same or modified proposal if it is responsive to any of the topics listed in this section.

For Phase II, no separate solicitation will be issued and no unsolicited proposals will be accepted. Only those firms that were awarded Phase I contracts, and have successfully completed their Phase I efforts, will be invited to submit a Phase II proposal. Invitations to submit Phase II proposals will be released at or before the end of the Phase I period of performance. The decision to invite a Phase II proposal will be made based upon the success of the Phase I contract to meet the technical goals of the topic, as well as the overall merit based upon the criteria in section 4.3. DoD is not obligated to make any awards under Phase I, II, or III. DoD is not responsible for any money expended by the proposer before award of any contract. For specifics regarding the evaluation and award of Phase I or II contracts, please read the front section of this solicitation very carefully. Every Phase II proposal will be reviewed for overall merit based upon the criteria in section 4.3 of this solicitation, repeated below:

a. The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.
b. The qualifications of the proposed principal/key investigators, supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.
c. The potential for commercial (defense and private sector) application and the benefits expected to accrue from this commercialization.

In addition, the OSD SBIR Program has a Phase II Plus Program, which provides matching SBIR funds to expand an existing Phase II contract that attracts investment funds from a DoD acquisition program, a non-SBIR/non-STTR government program or Private sector investments. Phase II Plus allows for an existing Phase II OSD SBIR contract to be extended for up to one year per Phase II Plus application, to perform additional research and development. Phase II Plus matching funds will be provided on a one-for-one basis up to a maximum $500,000 of SBIR funds. All Phase II Plus awards are subject to acceptance, review, and selection of candidate projects, are subject to availability of funding, and successful negotiation and award of a Phase II Plus contract modification. The funds provided by the DoD acquisition program or a non-SBIR/non-STTR government program must be obligated on the OSD Phase II contract as a modification prior to or concurrent with the OSD SBIR funds. Private sector funds must be deemed an "outside investor" which may include such entities as another company, or an investor. It does not include the owners or family members, or affiliates of the small business (13 CFR 121.103).

The Fast Track provisions in section 4.0 of this solicitation apply as follows. Under the Fast Track policy, SBIR projects that attract matching cash from an outside investor for their Phase II effort have an opportunity to receive interim funding between Phases I and II, to be evaluated for Phase II under an expedited process, and to be selected for Phase II award provided they meet or exceed the technical thresholds and have met their Phase I technical goals, as discussed Section 4.5. Under the Fast Track Program, a company submits a Fast Track application, including statement of work and cost estimate, within 120 to 180 days of the award of a Phase I contract (see the Fast Track Application Form on www.dodsbir.net/submission). Also submitted at this time is a commitment of third party funding for Phase II. Subsequently, the company must submit its Phase I Final Report and its Phase II proposal no later than 210 days after the effective date of Phase I, and must certify, within 45 days of being selected for Phase II award, that all matching funds have been transferred to the company. For projects that qualify for the Fast Track (as discussed in Section 4.5), DoD will evaluate the Phase II proposals in an expedited manner in accordance with the above criteria, and may select these proposals for Phase II award provided: (1) they meet or exceed selection criteria (a) and (b) above and (2) the project has substantially met its Phase I technical goals (and assuming budgetary and other programmatic factors are met, as discussed in Section 4.1). Fast Track proposals, having attracted matching cash from an outside investor, presumptively meet criterion (c). However, selection and award of a Fast Track proposal is not mandated and DoD retains the discretion not to select or fund any Fast Track proposal.

Follow-On Funding

In addition to supporting scientific and engineering research and development, another important goal of the program is conversion of DoD-supported research and development into commercial (both Defense and Private Sector) products. Proposers are encouraged to obtain a contingent commitment for follow-on funding prior to Phase II where it is felt that the research and development has commercialization potential in either a Defense system or the private sector. Proposers who feel that their research and development have the potential to meet Defense system objectives or private sector market needs are encouraged to obtain either non-SBIR DoD follow-on funding or non-federal follow-on funding, for Phase III to pursue commercialization development. The commitment should be obtained during the course of Phase I performance, or early in the Phase II performance. This commitment may be contingent upon the DoD supported development meeting some specific technical objectives in Phase II which if met, would justify funding to pursue further development for commercial (either Defense related or private sector) purposes in Phase III. The recipient will be permitted to obtain commercial rights to any invention made in either Phase I or Phase II, subject to the patent policies stated elsewhere in this solicitation.

Contact with DoD

General informational questions pertaining to proposal instructions contained in this solicitation should be directed to the topic authors and point of contact identified in the topic description section. Proposals should be electronically submitted. Oral communications with DoD personnel regarding the technical content of this solicitation during the pre-solicitation phase are allowed, however, proposal evaluation is conducted only on the written submittal. Oral communications during the pre-solicitation period should be considered informal, and will not be factored into the selection for award of contracts. Oral communications subsequent to the pre-solicitation period, during the Phase I proposal preparation periods are prohibited for reasons of competitive fairness. Refer to the front section of the solicitation for the exact dates.

Proposal Submission

Proposals shall be submitted in response to a specific topic identified in the following topic description sections. The topics listed are the only topics for which proposals will be accepted. Scientific and technical information assistance may be requested by using the SBIR/STTR Interactive Technical Information System (SITIS).

It is required that all bidders submit their proposal cover sheet, company commercialization report and their firm's technical and cost proposal form electronically through the DoD SBIR/STTR Proposal Submission Web site at http://www.dodsbir.net/submission. If you experience problems submitting your proposal, call the help desk (toll free) at 866-724-7457. You must include a Company Commercialization Report as part of each proposal you submit; however, it does not count against the proposal page limit of 25 pages. Please note that improper handling of this form may result in the proposal being substantially delayed. Information provided may have a direct impact on the review of the proposal. The proposal submission Web site allows your company to come in any time (prior to the proposal submission deadline) to edit your Cover Sheets, Technical and Cost Proposal and Company Commercialization Report. We **WILL NOT accept any proposals which are not submitted through the on-line submission site.** The submission site does not limit the overall file size for each electronic proposal, only the number of pages is limited. However, file uploads may take a great deal of time depending on your file size and your internet server connection speed. You are responsible for performing a virus check on each technical proposal file to be uploaded electronically. The detection of a virus on any submission may be cause for the rejection of the proposal. We will not accept e-mail submissions.

The following pages contain a summary of the technology focus areas, which are followed by the topics.

Defense Health Program Biomedical Technology Focus Area

The Department of Defense is aggressively pursuing unified Force Health Protection and Deployment Health strategies to protect Service members and their families from health hazards associated with military service. Toward that end, DoD is undertaking technology development programs that save lives and promote healthy individuals, units and communities while improving both force morale and warfighting capabilities.

The operational force is exposed to health threats throughout the operational continuum, from CONUS fixed facilities (garrison, base, ashore) through deployment, employment, and redeployment. DoD is developing policy and procedures to assess occupational and environmental health threats for all locations.

When Force Health Protection capabilities are fully implemented, commanders will have a more complete view of potential health threats. Integration of assessments from health databases and other assessments from intelligence (e.g., about land mines, directed enemy fire, fratricide) and safety (e.g., about injuries, vehicle accidents, explosives, aviation mishaps) will provide a framework for identifying future medical technology capabilities necessary for Force Health Protection.

Ensuring the health of the force encompasses several key capabilities:

- To mobilize, deploy and sustain medical and health support for any operation requiring military services;
- To maintain and project the continuum of healthcare resources required to provide for the health of the force;
- To operate in conjunction with beneficiary healthcare; and
- To develop training systems which provide realistic rehearsal of emergency medical and surgical procedures and unit-level medical operations.

These capabilities comprise an integrated and focused approach to protect and sustain DoD's most important resource—its Service members and their families—throughout the entire length of service commitment.

The Office of the Secretary of Defense believes that the small-business community can be effective in developing new technology-based approaches to needs in force health protection. Three broad capability areas of particular interest are tools and techniques for near real-time surveillance of the health threats and health status of the Force, for epidemiology research, and for delivery of health education and training. These are described in more detail below:

- Health Surveillance Planning and Decision Support Tools: Tailorable and targeted software applications that are integrated into the Military Health System's backbone of installed information systems are the essential enabling technology for surveillance. Applications in the areas of decision support tools, data and knowledge management, information visualization technologies including geospatial tools, and artificial intelligence-based appliqués for essential analyses are needed. It is expected that the applications would produce a comprehensive system of risk based assessments, predictions, and courses-of-action utilizing epidemiological, intelligence, environmental exposure, and health information concerning deployed forces. The applications should also allow for predictive modeling of medical readiness scaleable from individuals to the aggregated Force, given such data streams as reported real and somatic symptoms.

- New Methods to Monitor Health Status and Clinical Laboratory Data: Monitoring of health status during deployments is necessary to determine etiologic factors of deployment related health change. Data and information analysis tools are needed to collect and harmonize disparate data and information sources and to provide health status surveillance pre- or post-injury to medical information consumers within and outside of military medical channels. Health monitoring should be for a limited set of indicators, and should yield an unambiguous interpretation of health status. Projects are required to have a strong biological basis and be sensitive to changes in health status based on either real-time measurements from warfighters in an operational environment, clinical laboratory data sources, and/or recorded in-patient or out-patient or trauma registry data.

- Medical Training and Learning Tools: Developing and maintaining skills among the personnel of the Military Health System is an important aspect of deployment health. Advanced distributed learning, simulation-based training and other computer-based training technology should enable all health-care personnel to plan, respond and manage the future medical missions, and should assist medical professionals to maintain clinical knowledge and skills. Tools that can be extended to use by the general military population for proactive preventive medicine are desirable. Tools should be based on existing medical and allied health knowledge, should be universally accessible, should allow for unlimited practice, and should be SCORM-compliant in content and in delivery modalities.

The Defense Health Program Biomedical Technology topics are:

OSD08-H11	Medical Simulation-Based Training System for Rapid Trauma Skills Training (Army)
OSD08-H12	Sim-Game based Training System for Scene and Patient Management Following Blast Injury from Explosives Including Improvised Explosive Device (IED) (Army)
OSD08-H13	Improving Patient Safety by Enhancing the Medication Delivery and Administration Process into a Seamless System that is Integrated into the Electronic Health Record (Army)
OSD08-H14	A Biomechanical Model for the Investigation of Blast Traumatic Brain Injury (Army)
OSD08-H15	Interactive Game-Based System for Psychological Health Education (Army)
OSD08-H16	Integrated Clinical Environment (ICE) Supervisor (Army)
OSD08-H17	Evaluation of Hearing-Critical MOS/Mission Performance Capabilities (Army)
OSD08-H18	Pro-Active Dynamic Accommodating Socket (Army)

Materials Technology Focus Area:
Mitigating Lead-free Finish and Solder Risk

The military/aerospace industries are seeking to mitigate issues in electronic system design, production, and repair related to lead-free solders and surface finishes. In the last three years, the European market driven movement to use lead-free surface finishes on electronic components has eliminated about 75% of the supply chain availability of electronic components suitable for current military electronic designs. The trend toward lead-free assembly processes also is impacting military and aerospace systems.

Because of military/aerospace requirements for high reliability with long service life under demanding operating conditions, any transition from proven and qualified materials and processes to new technology must be undertaken with discipline and substantiated with data and analysis. The failure modes associated with lead-free solders are significantly different from those of the well understood tin-lead solder alloys currently in use. The elimination of lead also greatly increases the probability of "tin whisker" related failures. This is especially significant for mission critical systems.

While much of the commercial electronics industry is shifting to the use of lead-free solders and finishes for circuit boards and components, currently, the military/aerospace is concentrating on meeting its contractual reliability and service life requirements.

Generally, the reliability models of solder and components, reliability test protocols, assembly and rework processes involving lead-free solders and surface finishes and combinations with tin-lead solder are immature as compared to the heritage tin-lead systems. The performance of lead-free soldered assemblies is different from heritage tin-lead eutectic solder alloys when used in high-performance applications. The major risks are (1) tin whiskers associated with high-tin-content lead-free solder and finishes, and (2) solder joint reliability risks associated with alloys with material properties that are significantly different from those of traditional tin-lead alloys.

The Materials Technology topics are:

OSD08-M01	Assessment of Reballing Methods for Ball Grid Array (BGA) Devices (Navy)
OSD08-M02	Physics of Failure Based Electronics Reliability Analysis Software (AF)
OSD08-M03	Assessment and Modeling of Shock and Vibration Performance of Lead-Free Alloys (Navy)
OSD08-M04	Development and Validation of Tin-Whisker Growth Model and Accelerated Testing (Army)

Energy and Power Technology Focus Area:
Thermal Management

Technology advances in electric power generation, distribution, and use are enabling new, transformational military capabilities. Advanced power and energy technologies are providing the critical concepts, architectures, and systems to enable this revolutionary warfighting advantage. Integrating and distributing power on ships, aircraft, ground vehicles and other platforms for use in advanced weapon and survivability systems, leads to significant enhancements in platform flexibility, survivability, lethality and effectiveness. The Army's transformation challenge is to develop a smaller, lighter, and faster force, utilizing hybrid electric drive, electric armament and protection, and a reduced logistical footprint. The Navy is developing future ship concepts that integrate electric power into a next-generation architecture which enables directed energy weapons, electromagnetic launchers and recovery, new sensors, as well as supporting significant fuel, maintenance, and manning reductions. The Air Force needs electric power to replace complex mechanical, hydraulic and pneumatic subsystems, and also enable advanced electric armament systems. Improved batteries/power sources will support the individual soldier by permitting longer mission durations and reduced weight borne by the soldier. Space based operational capability improvements include a more electric architecture for responsive and affordable delivery of mission assets, and powering space based radar systems.

More electric and all-electric systems and platforms have distinct technological advantages but also penalties; predominately a marked increase in the amount of heat generated by all the electronic components. Shrinking component sizes are resulting in increasing volumetric heat generation rates and surface heat fluxes in many devices. Power system components such as batteries, capacitors, power semiconductors, generators, pulsed power sources and other components have thermal design issues when their performance is pushed to deliver higher and higher power. These thermal management issues are a key metric in the overall performance and have significant effects on the reliability, maintainability, cost, weight and volume of the equipment.

The Energy and Power Technology topics are:

OSD08-E09	Contaminant Resistant High Power Density Fuel Cells for Military Application (Navy)
OSD08-E10	Thermodynamic Vapor Quality Management, Mixing and Stability Enhancement in Steady and Transient Flows of Refrigerants (AF)
OSD08-E11	Cost Effective Coatings for Low-Friction Ducting (Navy)
OSD08-E12	High Speed Compact Vaneaxial Fans (Navy)

Cognitive Readiness Technology Focus Area:
Accelerated Learning

There has been significant DoD investment in game technology over the last decade. While it is difficult to dispute the entertainment value of games, their impact on training is not as well understood. Game development for entertainment purposes often excludes instructional elements and technologies that are beneficial to training, because they do not enhance entertainment value. This theme supports developing serious game technology that demonstrably accelerates learning and provides tools to evaluate the effectiveness of the learning. This theme extends the scope of serious games from a focus on tactical and kinetic skill sets to those that are crucial for non-kinetic and strategic actions.

The gaming universe is incredibly diverse, and even the most successful games are only played by a fraction of the population. There are, however, many common human systems elements to most games. While the keyboard, mouse, and joystick are ubiquitous, novel interfaces such as the Nintendo Wii controller add an entirely new dimension. It is common practice to render virtual worlds in a first and third person perspective and add small abstract maps to aid in navigation. Current games have minimal or generic environments and characters. Future games that include accurate geospatial, social and cultural environments and characters will provide valuable learning tools for the development of non-kinetic and strategic strategies and skills. Another critical aspect is communication both with adjacent and remote players. The effectiveness of these human systems interfaces on learning needs to be addressed. Additionally, the creation of effective content to accelerate learning and adapt learning to differing individuals needs further development. Recent and ongoing research has identified numerous psycho-physiological signals that may be useful markers for skill or knowledge acquisition, or for assessing general cognitive workload capacity. Robust sensors for collecting these signals in real-world environments are now available in prototype or COTS form. Incorporation of closed-loop neuro-physioloical feedback, i.e. augmented cognition technologies, to the instructor and trainee are one of the critical components that will help transform today's gaming technologies into useful training tools. Processing methodologies for assessing and evaluating these signals in real-time have also been the subject of intense research over recent years. Finally, the tools and technologies developed as part of this focus and theme will enable a new generation of learning tools. Current challenges facing the US Marine Corps and US Army, such as, tactical-to-operational planning handoffs in the non-kinetic environment, will be transformed in that the solution set will change from games that train to structured learning tools to that accelerate training and tools that begin to blur the distinction between training and operations.

This theme supports research topics that utilize innovative technologies that can be used to accelerate learning and to push the envelope on providing new training capabilities for the deployed warfighter in organizational echelons from combat teams to Joint Task Force Headquarters. The focus of these topics should be on developing unique and operationally relevant technologies and content.

The Cognitive Readiness Technology topics are:

OSD08-CR5	Closed-Loop Real-Time Neurophysiologically-Driven Simulation-Based Training System (Navy)
OSD08-CR6	Providing Instruction and Practice through Game-Based Technology (Army)
OSD08-CR7	Learning the Human Terrain (Navy)
OSD08-CR8	Accelerated Learning through Serious Game Technology (AF)

OSD SBIR 083 Topic Index

OSD SBIR 083 Topic Descriptions

OSD08-CR5 TITLE: Closed-Loop Real-Time Neurophysiologically-Driven Simulation-Based Training System

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop an integrated system that collects, cleans, and processes neurophysiological, physiological, and performance-based data in real-time from individuals and teams training in currently fielded simulation based training environments then uses this processed data to drive closed-loop adaptive training mitigations.

DESCRIPTION: Today's Warfighter is challenged to acquire a broad range of tactically relevant skills ranging from basic marksmanship and close quarter battle skills to basic language proficiency and tactical cultural awareness. This research effort should combine approaches from applied cognitive neuroscience (Berka et al 2004; Scerbo et al, 2003), instructional/educational sciences (Fowlkes et al, 1998; Zachary et al, 1999), with simulation-based training methods (REF) to create effective instructional content that accelerates learning and provides a learning environment that is adaptive to the differing needs, capabilities, and skill levels of individuals.

It is critical to incorporate methods for calibrating physiological/neurophysiological driven assessment measures for individual trainees in a non-burdensome manner. All data collection, artifact removal, and processing for assessment of performance, skill acquisition, etc. must occur in real-time. Sensor systems should be robust, easy to don and doff, and easily maintained. The training mitigation system should include interventions that are empirically validated with the target simulation. The underlying software should include APIs that allow other developers to obtain artifact-cleaned data, as well as the processed performance assessments and allow externally developed modules to drive both new and existing training mitigations. The result should be an integrated, user-friendly system that readily plugs in with existing training simulations and serves as a base architecture for further adaptive training systems development.

PHASE I: Determine the feasibility of integrating the various modules. Develop a comprehensive plan indicating the transfer of I/O between modules. This plan should include an indication of the existing simulation based training systems that will be targeted for initial development.

PHASE II: Develop data collection, artifact removal, performance assessment processing, training mitigation code, and APIs as described above. The development of these elements will be based on the plan outlined in Phase I

PHASE III: Refine the functional code provided in Phase II, and conduct a validation of the collective capabilities of this system. In addition, develop the user interfaces to yield a finished product. This technology will be directly applicable to a wide variety of computer-based training and rehabilitation needs.

REFERENCES:

1. Berka, C.; Levendowski, D.J.; Cvetinovic, M.M.; Petrovic, M.M.; Davis, G.; Lumicao, M.N.; Zivkovic, V.T.; Popovic, M.V.; Olmstead, R. (2004) "Real-Time Analysis of EEG Indexes of Alertness, Cognition, and Memory Acquired With a Wireless EEG Headset." International Journal of Human-Computer Interaction, Volume 17, Issue 2, pages 151 – 170.

2. Scerbo, M.W.; Freeman, F.G.; Mikulka, P.J. (2003) "A brain-based system for adaptive automation." Theoretical Issues in Ergonomics Science, Volume 4, Issue 1 & 2, pages 200 – 219.

3. Fowlkes, J., Dwyer, D. J., Oser, R. L., & Salas, E. (1998). Event-based approach to training (EBAT). International Journal of Aviation Psychology, 8(3), 209-221.

4. Zachary, W., Cannon-Bowers, J., Bilazarian, P., Krecker, D., Lardieri, P., & Burns, J. (1999). The Advanced Embedded Training System (AETS): An intelligent embedded tutoring system for tactical team training. International Journal of Artificial Intelligence in Education, 10, 257-277.

OSD08-CR6 TITLE: Providing Instruction and Practice through Game-Based Technology

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: To develop methods that will combine instruction and game-based practice to train "how to" and "when to" perform in Contemporary Operating Environment (COE) scenarios.

DESCRIPTION: Quality training includes a number of components: (1) identification of training objectives, (2) presentation of procedures and other knowledge components (3) demonstration of how tasks are performed, and (4) practice with expert feedback. Game-based technology has become an increasingly popular method for conducting military training. Games have been used primarily to provide environments for demonstrating correct performance and/or environments for practice. They provide a means to accelerate gaining experience through exposure to relevant scenarios and practice of not only "how to" but "when to" perform military tasks. There are two categories of games that have been designed specifically for training. The first category of training game is intended for training of tactics, techniques and procedures. Examples of this type game are VBS2, OLIVE and Ambush. The other type of military training game has a specific skill training objective. An example of this type game is BiLAT, which trains bilateral negotiation skills. Since games do not generally deliver all of the components of quality training, it is difficult to assess their effectiveness without taking into account the other components of the training process. To be effective as a stand-alone solution game-based training should include instruction on new skills, procedures and knowledge. Instruction could be presented prior to practice with the game or as remedial help after mistakes are made. The approach would depend on the training strategy employed. In addition to designing training approach around training games that include all the elements of effective training authoring techniques are needed that are capable of producing instructional content and practice scenarios.

Phase I: The objective of Phase I is to design approaches to total training solutions that are centered on game-based demonstration and practice. Methods for incorporating instruction into tactical and skills and knowledge games will be developed including plans for implementation of these strategies given currently existing games or game engines. This phase will develop two sets of training objectives and plans and rationale for how they would be trained. The first set of objectives will focus on training notional tactics, techniques and procedures that might have emerged from lessons learned in the COE. The second set of objectives would train procedures, skill and knowledge necessary to perform a task or function. In both cases at least the demonstration and practice phases of training would be enabled by game-based technology. The contractor should consider the possibility of completely embedding the instruction and practice within the same game context.

Phase II: In this phase the contractor will carry out the plans developed under Phase I. The contractor will develop or adapt an authoring capability for the instructional content to be presented and the scenarios to be utilized for demonstration and practice. The authoring capability will be able to instantiate scenarios and instruction in the game environment and provide training support packages for instructors and/or trainees. Given the nature of the training for the two applications different approaches may be needed for tactical vs. skill/task based training. After development of the instruction and authoring capability the contractor will conduct an evaluation of the capability of military trainees and instructors to utilize and learn from the prototype training applications.

Phase III Dual Use Applications. In this phase the contractor shall further develop the authoring tools begun under Phase II. Applications in a wide variety of fields is possible particularly police and emergency services and homeland security are possible. The potential for these applications will be developed under Phase III.

REFERENCES:
1. Bonk, C.J. and Dennen, V.P. (2005) Massive Multiplayer Online Gaming: A Research Framework for Military Training and Education (Technical Report 2005-1). Washington, DC: Office of the Under Secretary of Defense for Personnel and Readiness.

2. Hays, R. (2005) The Effectiveness of Instructional Games: A Literature Review and Discussion (Technical Report 2005-004). Orlando, FL: Naval Air Warfare Center, Training Systems Division.

3. O"Neil, H.F., Wainess, R. & Baker, E.L. (2005, December) Classification of Learning Outcomes: Evidence from the Computer Games Literature. The Curriculum Journal, 16(4), 455-474.

KEYWORDS: multiplayer games, game engines,simulation, training authoring, game-based technology

OSD08-CR7 TITLE: Learning the Human Terrain

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: ONR 30, Human Performance, Training, & Education

OBJECTIVE: Develop a serious game that efficiently teaches the social, cultural and communication skills necessary for Marines and Soldiers to function in the irregular warfare and stability and reconstruction environments. The serious game must provide real time cognitive state assessment capabilities allowing the game to automatically tailor the challenges of the game to the individual's current knowledge and skill level.

DESCRIPTION: The Irregular Warfare battlefield and the Department of Defense's mission has a new emphasis on security, stabilization, transition and reconstruction efforts requires new capabilities for Marines and Soldiers in the area of social, cultural and communication skills. Specifically, Marines and Soldiers must have the cross-cultural communication skills to effectively interact with contested populations. This require knowledge of social and cultural information and communication skills, both verbal and non-verbal. Serious games focused on cross-cultural communication skills have the potential to provide a relatively inexpensive, deployable and widely available training tool for all Marines and Soldiers.

Several serious games are being used to train cultural and language skills using experiential learning paradigms. However, the learning efficiency of these serious games has not been examined. Currently, the salient features of these games that facilitate language and culture learning are not known. Understanding the characteristics of the immersive environment that facilitate learning will improve the efficiency of learning and reduce training times. The implementation of real-time cognitive state assessment will further increase the efficiency of learning by tailoring the training to the individual.

This SBIR will develop a compelling social, cultural and communication training tool that will provide high levels of learning efficiency by tailoring the training to the individual based on real time cognitive state assessment.

PHASE I: Phase I will develop a complete concept plan, concept design for the overall system and a simple prototype. Phase I should identify the technology limitations and risks, describe the storyboard, and provide the design of the feedback system that will be implemented to individualize the training.

PHASE II: Build and demonstrate the prototype system. Demonstrate the ability to individualize the training. Demonstrate metrics for improving the efficiency of training.

PHASE III: Phase III will result in fully functional, validated training tool. This technology will be directly applicable to other organizations that work in the irregular warfare and stabilization and reconstruction environments, including Department of State, Department of Commerce and Non-Governmental Organizations.

KEYWORDS: Accelerated learning, cultural training, language training, augmented cognition, Game-based training, Socio-cultural modeling, PMESII

OSD08-CR8 TITLE: Accelerated Learning through Serious Game Technology

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Use of serious games to train supervisors to detect and thwart cyber insider threats.

DESCRIPTION: Considerable concern and investment is going into defensive cyberwarfare to prevent enemies and potential enemies from penetrating DoD cybernetworks. Little attention or investment has been paid to training to detect and thwart threats to cybernetworks that come from U.S. personnel. As is the case with corporate and academic cyber crime, the DoD faces threats from employees who wish to maliciously harm cyber infrastructure. The motives for these attacks include; greed, revenge, expression of employment frustration, a desire to embarrass, and a range of other reasons. Supervisors need to know what behavioral signs to watch for that might indicate an employee intends to commit an insider crime. There are a variety of technologies for digitally watching over an employee's activities on their cyber workstations. However, in many cases the employees who intend harm are clever enough to overcome these automatic defenses. What is required in addition to the automatic defense systems are supervisors who are alert to behavioral markers of suspicious behavior or attitudes on the part of employees.

This SBIR topic solicits industry ideas about how serious games might be used to properly train supervisors to detect and thwart insider threats to cybernetworks. What is required is not just a game, but an instructional system that employs serious game(s) in addition to other instructional support features, aids, and instructional characteristics. The game system is meant to be used in the stand alone mode and must provide adequate instructional feedback both to the supervisor being trained and the instructor(s) who is training the supervisor. In addition to being able to be used in the standalone mode, the serious game instructional system should also be able to be used in an academic classroom setting.

A key part of the solicitation involves an exploration of technologies like closed-loop neuro-physioloical feedback, i.e. augmented cognition technologies, to the instructor and trainee. A major research goal of this work is to determine how such advanced technologies can be used to accelerate learning. Therefore, the proposals should provide a plan for measuring learning acquisition and retention while using the serious game instructional system. Ideally, the research plan will determine how much acceleration in learning has taken place when the serious game is compared to a more traditional form of instruction.

Phase I: Analyze the insider threat challenge in the U.S. military by reviewing documents and surveying cyber facilities and supervisors. In addition, survey some supervisors who do not have cyberwarfare as their primary work domain. Perform a literature review of the accelerated learning literature. Based on the analyses, develop a design for a serious game that could be used to train supervisors to detect and deter insider threat damage to cybersystems.

Phase II: Exercise the design produced in Phase I to develop a prototype serious game as part of a training system for insider threat training. In addition to the game, the training system should include training materials based on clear learning objectives and should have a performance measurement system that can assist in determining how well the trainee has learned anti-insider threat principles. Evaluate the effectiveness of the training system, including the game. Deliver specifications for the training system. Discuss lessons learned from the development process, and define optimal approaches for use of the prototype training system.

Phase III: The military is naturally more concerned about outsider threats to cyber systems than it is with insider threats. The developer should apply the training system to military domains in which insider threat is possible. In addition, the developer should explain why this training goes beyond the training a supervisor normally gets in the course of determining whether any of their employees are having behavioral problems.

REFERENCES:
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2. Doolittle, P.E. and Camp, W.G. , "Constructivism: The Career and Technical Education Perspective," J. Vocational and Technical Education, vol. 16, no. 1, 1999;

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4. Greitzer, F.L., Moore, Andrew, P., Cappelli, D.M., Andrews, D.H., Carroll, L.A. and Hull, T.D. Combating the insider threat. IEEE Security and Privacy. Vol. 6, No. 1, pp. 61-64.

5. Cappelli, D.M., Moore, A.P. and Shimeall T.J., Common Sense Guide to Prevention/Detection of Insider Threats, tech. report, Carnegie Mellon Univ., CyLab and the Internet Security Alliance, July 2006;.

OSD08-E09 TITLE: Contaminant Resistant High Power Density Fuel Cells for Military Application

TECHNOLOGY AREAS: Ground/Sea Vehicles

OBJECTIVE: Develop materials, processes, designs and demonstrate

DESCRIPTION: According to the Defense Science Board Energy Report, improving the endurance of operational forces by producing more “effect” for less “is one of the corner stone concepts to achieving enhanced military energy security. Recent advances in fuel processing technologies enable the utilization of Fuel Cell systems as power generators for Marine Corp and Army applications. Fuel Cell systems in this role could operate at efficiencies as high as 55%, allowing for lower fuel consumption, while prototype fuel cell generators are currently at approximately 40%. They tend to produce less heat and noise signatures than traditional generators and provide modular design options that dramatically improve the ease with which to perform general maintenance and to conform to a variety of platforms and applications. Additionally this can enable “right sizing”, the ability to have as much power as necessary per mission, and not operate an oversized generator. Fuel cells are also inherently environmentally "friendly" due to negligible NOx, soot and carbon monoxide production, compared to typical diesel generators.

The Department of Defense has invested in the technologies required to convert logistics fuel to a reformate stream. Though rich in hydrogen, this stream may contain impurities such as trace amounts of sulfur or CO, known to contaminate certain types of fuel cells. Additionally, the United States military operates in environments possibly rich with air pollutants due to battle zone contaminants and other mission issues. It is essential that Fuel Cells be capable of operating in these environments.. A contaminant tolerant fuel cell capable could additionally lead to lower maintenance costs and a smaller balance of plant with respect to air clean up and fuel processing thereby reducing overall system weight.

It is desired therefore to develop fuel cell stack technology that utilizes a reformate stream and air to produce DC power while minimizing the need for gas purification equipment for both the cathode and anode streams. The fuel cell power unit, which is the fuel cell stacks and balance of plant required to condition and control both the reformate and air stream, shall be designed to achieve or exceed the following goals:
• Conversion Efficiency: 50% based on LHV of Hydrogen
• Volumetric density: 75 watts/liter
• Gravimetric density: 100 watts/kg
• Stack Durability: 10,000 hours
• Stack Scalability: 2-100 kWe
• Starts/year: 50 starts
• Stack Inlet temperature: 120-200C
• Stack exhaust temperature: 120-220C

The system should be designed to operate with the following streams.
• Reformate stream composition in mole fraction:

HYDROGEN - 0.32
WATER - 0.30
CO - 0.01
CO2 - 0.14
METHANE - 0.01
N2 - 0.22
H2S - 10-50 PPM

• Water content may be reduced as necessary, provided that technology and BOP is sufficient to dry as necessary.
• Cathode stream composition shall consist of air with elevated levels of H2S, SO2, CO and salt air.

Proposals are encouraged to include development summary and performance data including fuel utilization of the proposed fuel cell stacks. Technologies with tested stack assemblies with scalable characteristics that demonstrate the ability to exceed the goals listed above are desired.

Phase I: Develop a conceptual design for a modular, fuel cell power unit to operate with the reformate gas properties and stated goals as provided above. The conceptual design will include performance models for static operation and 3D layout of the notional system in an integrated subsystem module. In addition, the concept design will also include a basis for operation including startup, shutdown, load pickup / reduction. A proof of concept operation of the notional system in a sub-scale would be beneficial to demonstrate performance with a simulated reformate stream and tolerance levels for sulfur and CO.

PHASE II: Develop a detailed design, including Process & Instrumentation Diagram (P&ID), and Failure Mode Effect Analysis (FMEA) of a fuel cell power unit at a nominal 500 kWe size. Conduct a sub-kW test to demonstrate degradation and the ability to meet durability goal. Construct a 10+ kWe prototype of the Phase I concept, to be delivered at the end of the phase II effort. In conjunction with this work, further refinements of static process model, 3-D conceptual layouts, component maintenance strategies, and notional operational performance, should be performed. Develop a dynamic model based upon the efforts of the Phase I concept, and design of the phase II prototype, that simulates the operability and transient performance of the fuel cell power unit.

PHASE III: The advanced technology design will transition to commercial and military fuel cell applications where the fuel cell stacks will be built and tested at full size with a reformate stream.

KEYWORDS: Fuel Cells

OSD08-E10 TITLE: Thermodynamic Vapor Quality Management, Mixing and Stability Enhancement in Steady and Transient Flows of Refrigerants

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

OBJECTIVE: Develop techniques and devices for regulation of thermodynamic vapor quality for the mixing of multiple streams of two-phase flow, with the goal of stable operation of two-phase thermal systems.

DESCRIPTION: Thermal management is quickly becoming a limiting factor for Department of Defense (DoD) systems, whether they are aircraft, spacecraft, or other platforms. Each of these systems is comprised of a large number of different subsystems, components, and materials which all play a role in thermal management. Any excess energy must be handled in the most efficient manner possible to meet mission goals. As a result, vapor cycle systems are being examined to transport energy from its point of origin to an ultimate sink. The DoD is developing advanced vapor cycle thermal management systems (TMS). Typically, these vapor cycle refrigeration devices utilize both series and parallel flow segments for heat acquisition at various locations within the platform. The subsequent transport and merging of streams exiting multiple evaporators forms a primary vapor cycle transport loop, in which the vapor is compressed and condensed at a high temperature. Ideally, the individual parallel flow segments would merge to be eventually transported to the vapor cycle compressor inlet as saturated vapor. Series heat transfer segments would allow downstream segment exit quality to be less than 100 percent, with subsequent

quality increases achieved by series heat transfer segments. It is desired to minimize the thermal resistance of the TMS to maximize the TMS to the heat sink available temperature difference. Typically, these parallel segments transport kilowatts of heat, and the entire TMS is envisioned to be capable of transporting hundreds of kilowatts of heat over distances from 1 to 10 meters. Heat loads in some of the legs are intermittent, and the ultimate condenser conditions can be transient, with peak loads approaching five times the average loads.

This effort seeks to explore phase separation, mixing enhancement, control, and/or wall heating methodologies to ensure that stable operation of the TMS segments and guarantee saturated and/or appropriate vapor conditions exist at the exit of each flow mixing segment, and ultimately as saturated vapor at the compressor inlet. The mixing segment needs to be able to handle a dynamic difference in the superficial mass flow rate (mass flow/area) of up to a 10-to-1 ratio existing between two inlet streams, and be able to process thermodynamic vapor qualities that can vary by up to 30 percent. The pressure drop through the mixing segment should be minimized. Variable speed compressors may be employed to improve the energy efficiency of the system. Any technique proposed must be capable of operating in extreme environments consistent with DoD applications, such as variable-g loading, inversion, and high-shock environments.

PHASE I: Construct and demonstrate a preliminary heat/mass transfer analytical model of candidate approaches identified in the Phase I proposal. This should identify potential control methods and stability issues of the system. Phase II test apparatus design should also be considered.

PHASE II: Build and demonstrate a laboratory-scale experimental test apparatus capable of evaluating series/parallel flow mixing and refrigerant quality regulation, sufficient to experimentally simulate steady/transient mixing, separation, and fluid control, representative of situations in nominal 1-kilowatt series/parallel segments of a full-scale TMS, using conventional fluorocarbon refrigerants.

PHASE III / DUAL USE: Military application: Advanced cascaded two-phase vapor compression cycle TMS, as well as advanced multi-evaporator two-phase TMS for land-, sea-, and air-based platforms. Commercial application: Commercial applications of this technology include any advanced two-phase system incorporating multiple evaporators, including potential aircraft and residential/industrial HVAC applications.

REFERENCES:
1. Benning, S.L. and Ostgaard, J.C., “Supplemental Cooling for Legacy Aircraft Avionics,” Proceedings of the 18th IEEE Digital Avionics Systems Conference, St. Louis, MO, October 1999, pp. 6.C.4-1 - 6.C.4-8, Vol. 2.

2. Lovell, T., Zielke, D. and Benning, S.L., “Augmented Avionics Cooling for Existing Aircraft,” SAE/AIAA 26th International Conference on Environmental Systems (ICES), Monterey, CA, July 1996.

KEYWORDS: thermal management, two-phase thermal management system, advanced vapor cycle, multiple-quality two-phase flow management, two-phase mixing, vapor quality, multi-phase flow, vapor-liquid mixing

OSD08-E11 TITLE: Cost Effective Coatings for Low-Friction Ducting

TECHNOLOGY AREAS: Ground/Sea Vehicles

OBJECTIVE: Develop cost-effective methods to apply low-friction coatings to military ventilation ducts made from galvanized steel or aluminum. Non-toxic and non-flammable coatings should significantly reduce airside frictional losses and improve resistance to corrosion within a marine environment.

DESCRIPTION: Thermal Management is a critical requirement for future military platforms with advanced electrical propulsion, weapon, and sensor systems. It is projected that future thermal loads will be an order of magnitude higher than today’s combatants. Recent advances attained from work in Army, Navy, and Air Force laboratories under the DDR&E Energy & Power Technology Initiative have led to demonstration of waste heat removal via evaporative cooling technologies of fluxes in excess of 103 W/cm2. However, it is expected that many

future and legacy electronic systems will continue to reject waste heat via air cooling into sealed compartments, adding load to already overburdened heating, ventilation, and air conditioning (HVAC) systems. In addition to ensuring the comfort and health of the crew, the HVAC system on military platforms is often a critical element of damage control systems.

To meet this challenge, various technology concepts have been identified to permit higher duct velocities and smaller chilled water and air distribution systems. Currently, the maximum air velocity in round duct is specified as 4500 feet per minute, 3500 feet per minute in rectangular duct. Ambient temperature variations between -20ºF to 150ºF are possible. Innovative research is sought to produce the next generation of near-frictionless ductwork. Cost effective approaches to install surface coatings are desired.

PHASE I: Develop advanced coatings enabling the doubling of maximum allowable airflow velocities within ventilation ducts with comparable pressure losses. Demonstrate method to apply treatments to galvanized steel or aluminum. Quantitatively analyze for consistent exposure and smoothness, including transitions at joints and flanges. Evaluate scalability, cost, safety, and added weight of surface treatments. A detailed report containing the design concept, cost estimate, performance testing approach, and identification of risks will be prepared to enable the government to evaluate the viability of proceeding with Phase II.

PHASE II: Demonstrate coating performance in a small ventilation system mockup. Ducts should be sized to provide a variety of airflow velocities. Performance data shall be taken on the baseline system and coated ducts at various airflows up to 9000 feet per minute, documenting pre-treatment cleaning, coating application, and post treatment drying/curing procedures, as well as weight of pre-treated and post treated ductwork. Airborne sound measurements shall be obtained at the various duct velocities. Develop Phase III transition plan including identification of risks.

PHASE III: Finalize development and qualify the coating application for use in a military environment. Specific items to be addressed are potential environmental or safety issues, flammability, corrosion resistance, shock resistance, vibration, durability, and use in a marine environment. Advanced coatings developed here would be suitable for use in commercial and home HVAC systems.

REFERENCES

1. 2005 ASHRAE Handbook: Fundamentals, ISBN 1-931862-70-2, Chapter 35.

2. M. Kuszewski and M. Zerby, “Next Generation Navy Thermal Management Program,” NSWCCD Technical Report TR-82-2002/12 (2002).

3. Frank, M. & Helmick, R., 21st Century Heating Ventilation and Air Conditioning (HVAC) System for Future Surface Combatants, 14 pp.

KEYWORDS: thermal management; ducts; coatings; heating, ventilation, and air conditioning (HVAC)

OSD08-E12 TITLE: High Speed Compact Vaneaxial Fans

TECHNOLOGY AREAS: Ground/Sea Vehicles

OBJECTIVE: Develop efficient, compact, and quiet vaneaxial fans operating at speeds over 10,000 revolutions per minute.

DESCRIPTION: Increasing use of electronic systems on military platforms continues to add load to already overburdened heating, ventilation, and air conditioning (HVAC) systems. Recent work in Army, Navy, and Air Force laboratories under the DDR&E Energy & Power Technology Initiative has largely focused on liquid cooling techniques. However, it is expected that many future and legacy electronic systems will continue to reject waste

heat via air cooling. Yet, these systems have changed little over the past 50 years. Without innovation or creativity, the default approach to meeting increased thermal load requirements on military platforms will involve installation of larger and heavier systems. The US Navy, for example, has 23 standard vaneaxial fan designs to provide airflows from 250 to 30,000 cubic feet per minute at varying total pressures of 2.5 to 7 inches of water. Five high pressure vaneaxial fan designs provide airflows from 1200 to 5400 cubic feet per minute at a total pressure of 14 inches of water. The standard vaneaxial fan design dates to the 1940s. Ground-based environmental control units typically use forward-curved centrifugal fans, which are susceptible to fouling by dust and other contaminants. Compact vaneaxial fans would allow greater design and orientation flexibility due to their compact, simple, and self-contained packaging.

Vaneaxial fans consist of a flanged cylindrical casing with stationary vanes and an internal concentric mounted electric motor, which rotates a bladed fan wheel at a maximum rotational speed of 3600 revolutions per minute. The electrical motor is air-cooled and the fan heat (power plus motor inefficiency) is an additional burden on the HVAC system. A typical standard vaneaxial fan providing 2000 CFM at 3.4 inches of water operates on 440 VAC, is 15.5 inches in diameter, 26 inches long, and weighs 180 lbs. Second generation, high pressure vaneaxial fans were designed using aerodynamic blade shapes. The efficiency was dramatically improved and the noise was substantially reduced. Application of these concepts to the lower pressure standard vaneaxial fan family, coupled with lightweight permanent magnet motors operating at substantially higher speeds, is one of the goals of this topic. Variable speed drives can also be used to create variable flow rates, reducing the required number of fan designs. Innovative research is sought to produce next generation compact, high-speed, highly efficient and lightweight vaneaxial fans.

PHASE I: Design a vaneaxial fan with an overall efficiency above 85 %, a 50% reduction in weight and volume, and an acoustic signature of less than 80 dBA at 1 meter. Develop analytical tools to evaluate performance of fan design at varying rotational speeds for a specified geometry (blade shape, rotor size, etc.). A detailed report containing the design concept, cost estimate, performance testing approach, and identification of risks will be prepared to enable the government to evaluate the viability of proceeding with Phase II.

PHASE II: Demonstrate a full scale vaneaxial fan sized for 2000 to 5000 cubic feet per minute air flow. Performance data shall be collected at a variety of air flow rates, total system pressures and speeds. Validate analytic models developed in Phase I and evaluate scalability of design.

PHASE III: Design and develop the next series of vaneaxial fans using the knowledge gained during Phases I and II. This series of fans must meet military unique requirements such as shock, vibration, and EMI. Advanced fans developed here would be suitable for use in commercial and home HVAC systems.

REFERENCES:
1. MIL PRF 18953C - Performance Specification, Fans, Vaneaxial and Tubeaxial, Ventilation and Air Conditioning, Navy Shipboard, 14 Feb 2005, 25 pages.

2. MIL PRF 24755A - Performance Specification, Fans, Vaneaxial, High Pressure, Naval Shipboard, 31 May 2001, 22 pages.

3. M. Kuszewski and M. Zerby, “Next Generation Navy Thermal Management Program,” NSWCCD Technical Report TR-82-2002/12 (2002).

4. Frank, M. & Helmick, R., 21st Century Heating Ventilation and Air Conditioning (HVAC) System for Future Surface Combatants, 14 pp.

KEYWORDS: thermal management; vaneaxial fan; heating, ventilation, and air conditioning (HVAC); variable speed drive, permanent magnet motor

OSD08-H11 TITLE: Medical Simulation-Based Training System for Rapid Trauma Skills Training

TECHNOLOGY AREAS: Biomedical, Human Systems

OBJECTIVE: To develop &/or implement a simulation-based training system to assist in teaching and training trauma surgery skills. The primary target is an existing US Army military training program, but a secondary target could be other government agencies upon coordination with the government topic manager. The system could also have application to medical training programs in the academic and private sectors. The training audience is “soon-to-be-deployed” surgeons. The field of trauma surgery is dynamic, but the simulation technologies applied to improve trauma training are nascent. So, we seek the development / implementation of an innovative, adaptable, and expandable trauma training system.

Description: Deployed military surgeons, especially those with specialized training, e.g., ob-gyn, ophthalmology, orthopedics, are often required to perform general surgical and trauma surgical procedures required during wartime, with "open surgery" techniques, more often than the procedures they perform in their civilian or even peacetime military practice, which may be performed with "minimally invasive surgery" techniques.. As a result, they may be unprepared to perform them proficiently. Also, their specialty skills are prone to deteriorate during deployment. Thus, the US Army (as well as other DOD medical training programs) has a need to rapidly refresh skills of physicians going to and returning from forward based assignments. The very nature of traumatic injuries makes it difficult if not impossible to schedule traditional patient-based training based on educational objectives

This opportunity focuses on developing / implementing this trauma training system into demanding military medical training environment(s). This training has a direct impact on the care of our military personnel, and the criteria for success are weighted toward systems demonstrating the ability to assist the staff to accomplish their mission.

We seek a system that:
- is based on established educational objectives
- includes metrics upon which to judge proficiency performance
- tests the cognitive and psychomotor skills of trainees at the beginning of training
- identifies deficiencies in cognitive and psychomotor capability
- tests the cognitive and psychomotor skills of trainees at the conclusion of training
- teaches both cognitive and psycho-motor skills required of trauma surgeons
- creates a training program to correct them prior to deployment
- results in minimal negative impact, e.g., time, disruption, resources, of the training staff
- presents multiple trauma cases
- improves the quality of cognitive and psychomotor training, to teachers and/or students
- improves the efficiency of cognitive and psychomotor training, to teachers and/or students
- equals or reduces the cost of cognitive and psychomotor training, to teachers and/or students
- addresses virtual mentoring capability with potential to reduce time required by instructors and students
- assesses the training effectiveness of the system
- is SCORM-compliant
- employs open architecture principles

Optional but not required:
- A team training system that includes training for all members of a trauma surgery team, e.g., surgeons, nurses, technicians, etc.

PHASE I: Perform a feasibility study and analysis and develop a concept including discussion of how the system could be implemented. Identify the innovative technologies and approach proposed, technical risks of the approach, as well as the costs, benefits and schedule associated with development and demonstration of the prototype. Identify minimum system requirements and development tools. Demonstrate the foundational technology for simulation based trauma surgery training as well as the capability to expand it to train other surgical skills.

PHASE II: Demonstrate the prototype system’s capability to improve trauma surgery training and to rapidly adapt this technology for the training of other surgical skills. In the marketing plan section of the Phase II proposal, include recommendations for effective implementation and estimates of resources required to operate, maintain and sustain the system into the future.

PHASE III DUAL-USE COMMERCIALIZATION: This capability is expected to result in a system with military and civilian wide application for the training of trauma skills.

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1. Simulation in critical care and trauma education and training. The surgical patient. Current Opinion in Critical Care. 10(5):325-329, October 2004. Hammond, Jeffrey

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4. Development and Evaluation of the Advanced Trauma
Operative Management Course. J Trauma. 2003; 55:471–479. L. Jacobs, K. Burns, J. Kaban, R. Gross, V. Cortes, R. Brautigam, G. Perdrizet, A. Besman, O. Kirton

KEYWORDS: Keywords: Medical Modeling and Simulation, MM&S, Trauma Surgery, Trauma Training, Predeployment Training

OSD08-H12 TITLE: Sim-Game based Training System for Scene and Patient Management Following Blast Injury from Explosives Including Improvised Explosive Device (IED)

TECHNOLOGY AREAS: Biomedical, Human Systems

OBJECTIVE: Develop and demonstrate a prototype sim-game based training adjunct for Combat Medics with current emergency medical technician (EMT) and advanced skills training. It should focus on medical response(s) to explosive blast(s) to include scene management, triage and treatment of patients. The system should have the capability to function as a training AND skills certification system. It can be applicable to both military and civilian personnel.

DESCRIPTION: We wish to encourage innovative approaches to train for higher order skill sets and to train critical thinking. While scene and patient management following mass casualty incidents is trained in the Combat Medic Training program, IEDs blasts and other high explosive events have a limited amount of time to be trained. With proper training, both civilian and military prehospital medical providers will provide improved care to Soldiers and civilians, resulting in more victims surviving to reach definitive care. In the current conflict and for the foreseeable future, explosive devices, especially improvised explosive devices (IEDs) are the weapon of choice of terrorists. Because of the increasing risks, a pressing need has emerged: understanding of the mechanism of injury from explosives and how it differs from routine, low-velocity ballistic and blunt trauma. Also, the tactical issues related to responding to blasts are highly relevant to both military and civilian responders. For example, terrorists will often place a second device expressly to kill and wound the responders. This solicitation requires an innovative approach allows simulation of varied medical responses to an IED attack. We are seeking a system within the following general parameters:

1. “Simulation / strategy game” genre.

2. Scenario editing capability that allows development and adjustment of scenario variables such as patient numbers, arrival patterns, and patient risk levels, e.g., high-risk, low-risk, facility configuration, major equipment and supply items, and health care personnel staffing patterns.

3. Allow users to model, simulate, test, and identify consequences of various triage strategies.

4. Include embedded metrics that allow identification and analysis of consequences of implementing various strategies, e.g., management of time, equipment and supplies, clinical and support staff, medical treatment facility, and provide performance feedback to the user.

5. System should be designed to operate in either a “training mode” or “testing mode.” Testing mode should include embedded biometric tools to identify the trainee so the “sim-game” becomes the actual tool used certify proficiency.

7. System should be flexible enough to apply to other medical training / certification testing requirements, e.g., Advanced Combat Life Support, combat lifesaver.

8. Build using open architecture principles.

9. Considers or develops technologies that allows broad and cost-effective distribution.

10. Compliant with Shareable Content Object Reference Model (SCORM) standards. (http://www.adlnet.gov).

11. Can use standard curriculum for Emergency Medical Technicians (EMTs) and paramedics.

12. STRONGLY DESIRED but not required - explore the use of "intelligent tutoring" capability to take advantage of "teachable moments" for delivery of relevant curriculum.

PHASE I: Develop a concept plan and design for a prototype system to teach skills required by Combat Medics or civilian EMTs – already trained – who may be called on to respond to explosive blast(s). Plan should include scene / incident management triage and treatment of patients. In the concept plan, address the following items with respect to the Phase II requirements:
1. Describe and illustrate tool(s) under consideration.
2. Conduct a survey to identify what tasks could be certifiable in a gaming environment and to what specifications.
3. Model the proposed system configuration with respect to listed requirements.

PHASE II:
1. Build and demonstrate the prototype system.
2. Embed metrics for performance assessment.
3. Validate system performance with subject matter experts.

PHASE III: The focus will be on commercializing a system that is optimized considering cost, response, and quality parameters for both military and civilian sectors.

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1. Frykberg ER. Medical management of disasters and mass casualties from terrorist bombings: How can we cope? J Trauma 2002; 53:201-212.

2. Eastridge BJ. Things that go boom. Injuries from explosives. J Trauma 2007; 62:S38.

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4. Frykberg ER. Triage: principles and practice. Scand J Surg 2005; 94: 272-278.

KEYWORDS: medical training, Emergency Medical Technician, EMT, paramedic, medical simulation, advanced distributed learning, ADL, medical skills training, performance assessment, intelligent tutoring

OSD08-H13 TITLE: Improving patient safety by enhancing the medication delivery and administration process into a seamless system that is integrated into the electronic health

record

TECHNOLOGY AREAS: Information Systems, Biomedical, Human Systems

OBJECTIVE: The most common cause of preventable medical errors is a medication mistake. This SBIR addresses the urgent need to improve medication safety by drastically reducing the possibility of medication errors. Current advanced medication practice includes computerized physician order entry, an automated medication cabinet; a medication bar code; a biometric/password nurse identification and a patient bar code or biometric identification. Each is important but these elements are not interconnected and not recorded into the Electronic Health Record (EHR). The goal of this topic is to establish approaches to integrate the current steps of the medication delivery and administration process into a seamless system that is interconnected and recorded in the electronic health record. Critical safeguards and alerts should also be considered in this system thereby increasing patient safety, improving documentation and reducing staff work time.

DESCRIPTION: Based upon data from the American Hospital Association as analyzed by the Health Care Advisory Board,(1) 17 –30% of patients have one or more preventable serious adverse events during hospitalization. Convert this to a typical 350-bed community hospital with about 14,000 admissions and there will be 4000 preventable serious adverse events each year, of which 884 patients will have an adverse drug event. What is to be done to prevent these types of errors from occurring? The Institute of Medicine (IOM) in a landmark publication in 1999 wrote that as many as 98,000 Americans die as the result of avoidable errors in American hospitals each year.(2) The IOM report was entitled "To Err is Human." Well-educated and well-trained humans will make mistakes. Humans that double check will still make mistakes. Within the DoD, the Patient Safety Center's MEDMARX data indicate that 24% of the inpatient related errors are a result of prescribing error. The other two most prevalent areas are Administering (nurse) and Dispensing (pharmacy) which this proposal captures.

This SBIR topic seeks to develop a system to help reduce human errors in medication administration. This system will help to prevent an error from being made or to detect it early and cause a correction to occur before harm can develop.

In the current ideal setting, the physician enters into the computer an order for a specific medication for said patient, the pharmacy prepares the medication and places it in the automated medication dispensing system to be distributed on the nursing unit. The nurse then enters a password/biometric ID code into the Pyxis/Omnicell system to retrieve the medication for the specified patient. The medication should be barcoded and scanned by the nurse prior to administration. The patient's ID band barcode or RFID tag is also scanned prior to medication administration. The nurse then needs to document in the patient's record that the medication has been administered ensuring the patient's five rights; right patient, right drug, right dose, right route, and right time. As there are many steps in the medication prescribing, preparation, and administration process chances for error are great.

This ideal system is available today although relatively few hospitals have all of the elements noted above in place. Even for those that do, however, there is as yet no effective interconnection of all of the elements. As there are many steps in the medication prescribing, preparation, and administration process, chances for error are still high.

Currently some of these steps in the medication delivery and administration process are interconnected and recorded into the electronic health record, however, this SBIR topic seeks to take current process one step further by ensuring that all medication prescribing, preparation, delivery and administration systems are interconnected and recorded in the electronic health record. This system should also have critical safeguards and alerts (allergies, drug interactions, etc.) built in to further reduce the possibility of medication error.

This system is meant to assure that the nurse is accessing the correct patient, obtaining the correct drug, the correct dose for the right time from the medication cabinet and verifying this with the medication barcode system and giving it to the correct patient by verifying their barcode or biometric identification. The built in safeguards and alerts will notify the provider of any errors or mismatched information, patient allergies and potential drug interactions. This topic seeks to utilize this system as a means to improve the efficiency of the medication management process to include medication error reduction. Further it will record in the health record that the drug was indeed administered, by who, to whom and at what time.

A review of current literature shows that a pilot study was conducted at Jacobi Medical Center, Bronx, NY in collaboration with Siemens Business Services (SBS) (Norwalk, CT) and Precision Dynamics Corporation (PDC) (San Fernando, CA), to implement an RFID wristband system for patient identification and medication administration. A Tablet PC scanned the patient's RFID wristband prior to medication administration. The RFID wristband inlays were encoded with a unique patient ID number that once scanned; the patient's medical file was instantly accessible at the bedside. With this system, staff did not need to return to workstations to obtain patient data. Doctors and nurses could also use this system to order lab tests, enter notes on treatment, and update medication administration from the bedside.(4,5)

This system links the wristband (RFID) to the electronic health record (EHR) and the order entry system, which is a step in the right direction. This SBIR topic seeks to incorporate the medication dispensing system, barcoded medications, and nurse identification into in a seamless process that would be recorded in the EHR.

PHASE I: Phase I will develop a feasibility concept and a plan for developing and/or applying various innovative technologies for the development of a medication administration software integration system. This system should integrate the computer order entry system, current medication administration cabinets such as Pyxis and Omnicell, barcoded or RFID coded medications (solid, liquid, injectable and infusion,) positive patient identification and positive nurse identification (barcode or biometric) with the EHR. Integrating the data from these systems will provide a more effective medication administration data management system. Incorporating critical safeguards and alerts will also help to reduce the chance of medication error.

Phase I will deliver a report of the technical feasibility and engineering specifications to include a description of plans for performance objectives and validation for Phase II execution. This includes the preparation of plans and protocols for any required animal or human testing as well as seeking local and Army regulatory approvals for potential Phase II work.

Performance Objectives:

1. Determine the best way to integrate the computerized physician order entry system, Pyxis/Omnicell medication distribution systems, barcoded medications, barcoded or biometric patient and nurse identification with the electronic health record into one system with critical safeguards and alerts.

2. Demonstrate an understanding of the DOD/Army requirements for care of the soldier/sailor/airman/marine, their dependents and retirees in both military and civilian settings. The developed system needs to be able to be incorporated into the current military electronic health record.

3. Demonstrate an optimized system to ensure the correct patient gets the right medication and dose via the right route at the right time and is recorded in the electronic medical record. Patient allergies to medications must also be addressed and identified prior to inadvertent administration. Drug interactions and other critical safeguards and alerts may also be implemented as a further option.

4. Demonstrate alerts and/or notifications in the system to bring to the providers' attention the following: if the wrong patient is selected, the wrong medication, wrong dose, wrong route, wrong time, and if the patient is allergic to that medication. This information needs to be recorded for later summation and analysis of common errors and resultant needed system improvements.

5. The Phase I effort should develop an initial concept design of an integrated seamless system that does not increase the amount or complexity of the work involved for the nurse. This system should in theory make the workload easier and lighter.

PHASE II: Phase II will expand upon the Phase I proof of concept demonstration to develop, demonstrate and validate a working functional prototype of the medication administration software integration system. The system should be designed to be easily integrated into the current military electronic health record. The team will assess any requirements for Food and Drug Administration (FDA) approval during phase II and begin this process as required.

PHASE III: The focus will be on commercializing the developed system to be fieldable in both military and civilian arenas. As the IOM report states, between 44,000 and 98,000 deaths occur yearly due to medical errors. The Phase III product would successfully link RFID and or bio-identification technology that when modified to interface with differing electronic health record systems--ultimately decreasing medication errors in both the military and civilian healthcare systems.

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5. Association for Automatic Identification and Mobility (AIM). Hospital Gains Efficiency with Innovative RFID Pilot. Tuesday, August 2, 2005. Siemens Business Services. Retrieved December 28, 2006, from http://www.aimglobal.org/members/news/templates/healthcarecasestudies.asp?articleid=415&zoneid=32

KEYWORDS: Medication administration, bar coding, biometric identification, patient safety

OSD08-H14 TITLE: A Biomechanical Model for the Investigation of Blast Traumatic Brain Injury

TECHNOLOGY AREAS: Biomedical, Human Systems

OBJECTIVE: Develop a practical biomechanical tool that can directly support the investigation and assessment of the Traumatic Brain Injury (TBI) mechanisms resulting from blast overpressure exposure, and aid in the understanding of blast injury threshold. This tool shall be applicable to the design and analysis of blast TBI experiments and will provide an essential bridge to the analysis of real world cases using data obtained in a clinical setting. The tool shall be applicable to laboratory animal blast TBI experimentation. Existing blast overpressure pathological and mechanical data can be used in development of the model. It should also be versatile enough for use in overcoming the scalability issues among small and large animal models and humans and for elucidating the load transmission paths through the cranium and into the intracranial contents of the head across species. Proposals outlining biological experiments will not be considered. Successful proposals may include, but are not necessarily limited to, knowledge of blast overpressure physics, engineering, tissue properties and anatomy, and computational modeling.

DESCRIPTION: The Army's medical community is in need of research tools that are effective in the analysis of TBI mechanisms from blast loading. Explosive blast has emerged as a leading cause of both diagnosed and undiagnosed head trauma incurred in combat. While injury patterns in recent conflicts involving the US are similar to those for previous conflicts, advances in protective body armor coupled with improved medical care have contributed to the reduction in U.S. warfighter mortality. Therefore more warfighters are surviving with injury conditions such as blast TBI. The current operational experience points to the need for the development of tools to aid in the understanding of the wounding process, injury thresholds, and the development of effective countermeasures. These tools can be used in the analysis of the biomechanical interaction between the blast wave and the complex head shape. This interaction is complicated by induced skull deformations which affect the pressure conditions in the brain surface cerebrospinal fluid and thus the internal stress and stress gradient states in the brain. The interaction also involves the propagation of pressure through various internal pathways through the cranium and the intracranial contents. This multiphasic environment is challenging and involves the shock interaction with complex geometries as well as biological soft and hard tissue solids as well as fluids such as cerebrospinal fluid and

blood and their incompressibility. This is the essence of the injury mechanism or the wounding process which is subject to the energy localization and thus damage in the brain resulting from the geometric and material makeup of the head.

PHASE I: Produce and demonstrate feasibility of a phylogenetically low (inanimate surrogate or rat model) computational model capable of investigating blast shock loading on the head as well as biomechanical response of the cranium and the intracranial contents for effects of direct blast pressure for a range of relevant blast loadings.

PHASE II: Develop and produce the computational model as part of a comprehensive tool for the investigation and analysis of blast-induced TBI. This model shall be able to use existing experimental blast injury data and shall aid in the design of sophisticated TBI experiments to elucidate operative mechanisms of injury and to aid in the determination of blast injury thresholds. The model shall be able to apply to the head real world blast pressure from blast data incorporating complex shock interactions. The model shall contribute to the outstanding scalability question relating small and large animal models as well as the relationship of animal models to the human.

PHASE III: The tool to be developed under this effort is intended for use in support of warfighter research efforts within the military to contribute to the prevention and treatment of blast TBI. It is however, also applicable for use in a wider range of applications and can support a broader set of customers. The production tool is intended to be a standalone utility which can be used to investigate and analyze experimental head injury as well as aid in the understanding of reconstruction of real world TBI events. Federal and Defense agencies such as the National Institutes of Health and the Centers for Disease Control, the Consumer Products Safety Commission and the US Department of Transportation, the Defense Threat Reduction agency and the National Ground Intelligence Center, can benefit from such a tool in the analysis of the causation, mechanisms, and thresholds of TBI in falls and violence, motor vehicle incidents, safety and protective helmets, and sports TBI. While the charter of many of these agencies is prevention, therefore requiring mechanism and threshold information in the design of counter measure or safety devices, other agencies are charged with advancing the proper diagnosis and treatment of blast TBI and are in need of analysis tools to support preclinical research models for blast TBI.

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2. Warden D. Military TBI during the Iraq and Afghanistan wars. J Head Trauma Rehabil 21: 398-402, 2006.

3. Okie, S. Traumatic brain injury in the war zone. N Eng J Med 352: 2043-2047, 2005.

KEYWORDS: blast overpressure, explosives, traumatic brain injury, preclinical models, protection, injury threshold, warfighter personal protection, helmet, improvised explosive devices, modeling

OSD08-H15 TITLE: Interactive Game-Based System for Psychological Health Education

TECHNOLOGY AREAS: Biomedical, Human Systems

OBJECTIVE: To develop a highly interactive PC or web-based videogame application with voice interactive capability for educating military service members about the need and availability of Psychological Health (PH) options and to familiarize the user with the military PH process. The goal is to educate the user about exploring PH options for themselves or others and to familiarize the user with available options. The game should strive to make users more likely to recognize PH issues and to seek treatment for themselves, their colleagues, and family members. In addition to the active-duty population, the application should be expandable to the VA and civilian populations.

DESCRIPTION: We are looking for innovative ideas that explore and harness the power of “advanced” interactive multimedia computer game technologies, that offer single-player interaction via stand-alone computer or internet web-based applications. The system should incorporate the best-practices of the videogame industry, including

intuitive controls, story-telling, user-feedback (for performance assessment), and high-quality graphics & sound. Scenario editing is desired, but not required. The current solicitation is not aiming to build entertainment, but a highly accurate and advanced simulation platform. Voice-recognition and voice-interaction are required, but contingencies should be provided for users who do not have access to systems capable of doing voice-recognition. Simulations can use either interactive video-clip technology or high-quality 3-D graphics and 3-D interaction. If computer graphics are used, the system should attempt to make full use of facial expressions, including microexpressions, and body language. The simulation should provide a conversational environment where the user can ask and answer simple questions provided by the simulated avatar(s). First-person shooter (or equivalent) game technologies will be considered for this solicitation. Development software must be based on mature simulation-technology with proven functionality and performance. Software flexibility needs to be achieved though a scenario editor whenever possible. Software should also maximize the use of scripting languages accessible by the end-user to modify basic aspects of the simulation. In addition to the visual representations on the computer screen, the system should also provide user feedback including, but not limited to, an after-action report. Proven track record for creating similar types of applications for the government is desired. Development plans should include the use of trained psychological health experts with experience providing services to military populations to help devise scenarios and strategy that are both safe and effective.

PHASE I: Development of a complete concept plan, concept design for the overall system and a simple working prototype. In this concept plan, address the following items with respect to the Phase II requirements:
1. Describe, illustrate, and storyboard a complete game scenario with the help of medical Subject Matter Experts.
2. Outline technology limitations and risks, including minimum system requirements.
3. Identify development tools for producing the simulation.
4. Devise a training concept and discuss how your application could be implemented

PHASE II:
1. Build and demonstrate the prototype system.
2. Embed metrics for performance assessment.
3. Start to validate system performance with subject matter experts (SMEs).

PHASE III: Issues associated with seeking psychological health services cut across military and civilian sectors. A system designed to help to educate and destigmatize psychological health issues would be useful in military, veterans, and civilian sectors.

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KEYWORDS: Game-based training, PTSD, Psychological Health, Behavioral Health

OSD08-H16 TITLE: Integrated Clinical Environment (ICE) Supervisor

TECHNOLOGY AREAS: Biomedical, Human Systems

OBJECTIVE: Develop a configurable trauma lifesaver assistant (a cart or pack) whereby the technical skills of a frontline caregiver can be augmented by an intelligent, integrated medical device system to rapidly stabilize and treat high acuity patients for example, by infusing fluids and administering analgesics to achieve pain relief and maintain homodynamic stability. The first-responder's skills will be augmented by real-time rule-based algorithms

performed by a supervisory device that can connect a network of medical devices conforming to the emerging Integrated Clinical Environment (ICE) standard. The system will deliver context-aware clinical management and decision-support, smart alarms, safety interlocks, and automated electronic record keeping, resulting in intelligent alarms to diagnose emerging problems and reduce errors during transport and treatment

DESCRIPTION: A trauma lifesaver assistant system is needed to facilitate emergency healthcare task performance and management such as rapidly infusing appropriate intravenous fluids and delivery of medications to save lives at the point of traumatic injury. Specialized care plans will be developed to implement selected resuscitation procedures making use of an interoperable system of medical devices. The system should leverage the emerging standard for the Integrated Clinical Environment (ICE), which characterizes the patient-centric ecosystem as comprising the patient, clinicians, interoperable medical-electrical (ME) equipment, and "information" about the patient and therapeutic care-plans [2]. The system will consist of an infusion pump for fluids and blood products, an intravenous medication delivery system, a ventilator, and sensing monitors (e.g. blood pressure and pulse oximetry).

In the management of high acuity injury or pandemic environments, supervising clinicians may interact with the patient, with ME equipment supporting the patient, and with many less-skilled care-providers. More generally, the ME equipment may be used to monitor and display patient physiological parameters and may also act on the patient in order to deliver fluid, medication or energy. Most point of care medical devices are designed to operate independently. The integration of individual medical devices into a patient-centric networked system for the care of a high-acuity patient/battlefield casualty/pandemic victims will enable an infrastructure of innovation in patient safety, treatment efficacy, and workflow efficiency. This automated clinical care delivery system relies on the development of:

- Medical device safety interlocks to produce error-resistant systems
- Clinical decision support requiring real-time integrated clinical parameters and procedural context
- Enhanced sensitivity and specificity of clinical alarm systems through the integration of physiological measurements, equipment status, and contextual information
- Monitoring of device activity and performance
- Automated system readiness assessment (prior to starting invasive clinical procedures)
- "Plug-and-play" device integration
- Physiologic closed-loop control, e.g. of medication, fluid delivery, and ventilation
- Comprehensive data collection for the analysis of near-misses and adverse events

The proposed trauma lifesaver assistant system uses an ICE Supervisor to support the following patient-centric capabilities:

- Provide safety interlocks
- Provide context-aware clinical decision support, and distribute integrated alarm conditions to relevant operators
- Set command input variables of other medical devices per operator-defined, context-appropriate rules in order to manage their operation (e.g. change fluid infusion rate or blood pressure cuff cycle interval)
- Assess the readiness of medical devices in a clinical environment to support specified functions or clinical workflow
- Perform integration of alarm conditions from multiple medical devices
- Perform automated record keeping
- Support integrated control of those features made available through the ICE interface

PHASE I: Understand the clinical requirements for delivery of lifesaver care and specify the required devices and interactions necessary to support such a system. The preliminary configuration of devices consists of a ventilator, an infusion pump for fluids, a pump of medication delivery through a preconfigured cassette, and sensor modules (e.g. pulse oximetry). Conduct research and gather data focused on previous and current work on integration and coordination of ME devices. These baseline data must be collected by a multidisciplinary group comprised of expert clinicians, engineers (e.g. Biomedical, Mechanical, Electrical, and Computer), programmers, and military personnel, especially combat medics and trauma-management physicians. Provide a detailed illustrative report describing the conceptual design as well as different applications of a proposed single-patient-centric ICE Supervisor. Identify design features and applications that will integrate data obtained via the ICE Network Controller; support operator (clinician) interaction with the system; display relevant procedural, device, and patient information; support real-time decision support rules to control networked ICE-complaint devices and provide real-

time alerts or other clinically relevant information; and improve the safety, quality, access and cost of medical care in subsequent phases of this project.

PHASE II: Design, develop and demonstrate a functional prototype of a trauma lifesaver assistant system based on an ICE platform including the following hardware and software advancements
• Provides a method of data display
• Provides a graphical clinical rules-creation tool to match workflow
• Implements clinical rules in real-time to coordinate ME devices for increased care, including context-aware clinical decision support, device actuation and safety interlocks (where indicated)
• Supports user authentication
• Incorporates open source software and industrial/government standards as much as possible to permit use with varied ICE platforms
• Can set command input variables of other medical devices, per operator-defined, context-appropriate rules in order to manage their operation
• Assesses the readiness of medical devices in a clinical environment to support specified functions or clinical workflow
• Performs integration of alarm conditions from multiple medical devices

PHASE III: Phase III will develop a process of translating clinical practice into machine manageable algorithms so that expert clinical management processes can be rapidly deployed for front line users. This will require conversion of clinical care requirements into protocols to be run by the trauma lifesaver assistant on a standards-based ICE-compliant platform. The patient centered clinical management system will improve the safety, access, quality and cost of military and private sector medical care. Phase III will down-select the use cases identified in previous phases, such as augmented and closed-loop control of fluid-management for trauma care, augmented analgesia administration, or intelligent ventilator management with smart alarms, and optimize instantiations of the system for deployment in specific application domains, while maintaining generalizability of the core platform. The ultimate goal of this development project is to provide a clinical environment management system that centers on the patient and provides the ability to integrate and coordinate various ME devices with clinician support for improved health care in high-acuity settings. It is the intent of this R&D to develop a dual-use military and private sector device that can implemented within each healthcare system. As medical device interoperability technologies continue to advance the private sector will also adopt this because it will allow small, specialized ME device manufacturers to integrate with other ME devices into a system that provides increased levels of health care over singular, standalone devices. Cost within the private sector is a major factor in business decisions to implement ME device interoperability technologies. This new patient centered clinical environment management technology can provide a scalable integration and coordination tool that clearly benefits the private sector healthcare equally as well as the DoD in improving healthcare delivery.

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KEYWORDS: Clinical Environment, ICE, ICE Supervisor, Medical Device, Interoperability, Integration

OSD08-H17 TITLE: Evaluation of Hearing-Critical MOS/Mission Performance Capabilities

TECHNOLOGY AREAS: Biomedical, Human Systems

OBJECTIVE: Develop, evaluate and implement an evaluation tool to assess MOS-specific, hearing-critical performance across a wide range of military occupational specialties.

DESCRIPTION: This topic is designed to create, assess, and validate a hearing test or battery of tests designed to evaluate an individual's ability to perform hearing-critical tasks specific to a variety of Military Occupational Specialties (MOS). Currently, hearing is evaluated by measuring hearing threshold levels through pure tone and/or

speech audiometry. The results of these tests determine eligibility for recruitment and retention purposes regardless of the service member's MOS. The H (hearing) component of the PULHES factors from the Military Physical Profile Serial System (MPPSS) is based on these audiometric thresholds and speech-in-noise testing. Distinctions are not currently made regarding specific hearing-critical factors of the MOS. These relevant factors are not currently considered in the diagnostic evaluation process.

Conventional audiometry measures an individual's sensitivity to isolated tones across the frequency range necessary for hearing and comprehension of conversational speech. Audiometry is useful for the diagnosis of specific disorders of hearing and can predict, with limited accuracy, the functional and social handicap of a hearing loss (Parving & Ostri, 1983). It does not, however, evaluate other mission unique factors of the auditory system which may be critical to the successful performance of a particular MOS. Examples include the ability to determine where a particular sound occurs in space (localization), to understand speech in highly reverberant environments, to understand distant speech, to detect specific sounds, to detect changes in the pitch and/or loudness of sounds, to understand speech in presence of broad band noise, to understand speech in the presence of competing speakers or other competing sounds, etc. (Soli, 2003).

Clearly, the hearing-critical performance of an infantryman (11B) is different than those required for an operating room specialist (68D) or an avionics communications equipment repairer (94L). Individuals with H1 audiograms (essentially normal hearing) may be sensitive to soft sounds but might exhibit poor speech understanding in less than optimum environments or experience difficulty locating the source of sound in a reverberant space. MOS-specific, hearing-critical measures might better determine if an individual should be assigned to or remain on a particular job or if prosthetic devices (e.g. hearing aids) or hearing protectors compromise job-specific auditory performance. Such measures might also identify training opportunities for those at risk of failing to meet retention criteria.

PHASE I: In Phase I acoustic-related MOS requirements will be identified and parameters established for six distinct MOSs. The identified enlisted MOSs will include the following: 11 series – infantry; 88 series – transportation; 91 series – medic; 19 series – armor; 18 series – special operations; 13 series – artillery. The parameters will be based upon task specific mission requirements necessary for each job specialty and subject to topic author approval. This phase will include the development of a prototype of the tool which will be inclusive of the parameters identified above regarding critical acoustic-related skills. The prototype will employ specific evaluation measures sensitive to the identified task parameters will be selected from current measures or designed to a specific intent.

PHASE II: In Phase II, strategies will be established based on the application of the parameters articulated in the development of the phase I prototype. Quantifiable performance measures will be developed through assessments of the reliability, validity, and responsiveness of the identified measures through laboratory testing. This will be coupled the ability to support real-time communicative capabilities for the Warfighter across the operational spectrum.

PHASE III: In Phase III, the intent of this tool will be to provide a venue through which critical MOS specific communication requirements may be determined. This tool will allow organizations to develop occupation-specific communication requirements, which will maximize organizational success through enhanced personnel selection processes. Moreover the tool provides similar application to non-military organizations, (i.e. law enforcement, security operations, air traffic controllers).

REFERENCES:
1. Parving A & Ostri B (1983). On objective criteria for hearing impairment and hearing disability. Scand Audiol 12: 165-169.

2. Soli S (2003). Hearing and job performance. Paper prepared for the Division of Behavioral and Social Sciences and Education of the National Research Council for the Committee on Disability Determination for Individuals with Hearing Impairment.

3. Hearing-Critical Tasks for Infantry (11B), Excel chart, 1 page.
The numerical ratings were provided by Human Factor Specialists at the US Army Infantry Center, Ft. Benning, GA and refer to the following:

1. The ability to perform this task is critically important for this MOS.
2. The ability to perform this task is important for this MOS.
3. While good to have, the ability to perform this task is not particularly important for this MOS.
4. The ability to perform this task is not at all important for this MOS.

4. Hearing-Critical Tasks for Transportation (MOS 88), 2 pages.

KEYWORDS: Speech intelligibility, noise induced hearing loss, speech reception threshold, occupational requirements, job performance measures, military occupational specialties.

OSD08-H18 TITLE: Pro-Active Dynamic Accommodating Socket

TECHNOLOGY AREAS: Biomedical, Human Systems

OBJECTIVE: Individuals with amputations should not be limited by their prosthesis. A socket should provide ultimate fit and accommodate wearer physiology regardless of activity, limb volume, or perspiration levels. A socket should be comfortable, and provide management of moisture within the socket, as well as improving the overall performance of the prosthesis as opposed to merely serving as a passive mounting device.

Specific metrics under this topic include but are not limited to:
SOCKET OPERATION:
- The socket should pro-actively sense changes in the limb and adapt real-time, as opposed to a retroactive reaction to pressures induced on the socket wall by the residual limb.
- Shape change should be instantaneous to respond to muscle contractions.
- Shape change should account for limb volume changes due to physiological conditions. These changes may occur over a longer period of time, and may not be consistent.
- The socket should adapt while remaining in perfect alignment and relation with the prosthesis.
- The adaptation should be a “complete-socket” response, as opposed to predetermined areas of change.
- Any energy source employed should be lightweight, long lasting, and allow for recharge through multiple methods such as disposable power pack, AD/DC power cord, DC generator, or power harvested by prosthetic ankles or knees designed to collect and store power.
- Use of lightweight, ultrasound transparent material is strongly encouraged.
- The new device should be able to function in a variety of environments including cold, heat, sun, water, and sand for example.
- The socket should be rigid enough to support body weight, yet flexible enough to accommodate anthropometric changes.

MOISTURE MANAGEMENT:
- Identify physiological response and adaptation to heat retention in elastomeric gel liners.
- Liner, or moisture management system, should maintain state of limb such that causes (e.g., limb-pistoning) of moisture-related friction and skin irritation are eliminated.
- Liner, or moisture management system, should inhibit development of skin conditions such as dermatitis and/or other bacterial growth.
- Liner, or moisture management system, should be durable, easily maintainable, easily donned and doffed.
- Liner, or moisture management system, should be able to be comfortably worn for extended periods of time as needed (i.e., > 24 hours.
- Liner, or moisture management system, should accommodate, and not interfere with, any sensing and/or dynamic shaping performed by the socket itself.
- Any energy source employed should be lightweight, long lasting, and allow for recharge through multiple methods such as disposable power pack, AD/DC power cord, DC generator, or power harvested by prosthetic ankles or knees

designed to collect and store power. However, it is preferred that the moisture management system not require power.
- Liner, or moisture management system, should be both lightweight and durable, exceeding those characteristics of currently used materials.
- The liner, or moisture management system, should be able to function in a variety of environments including cold, heat, sun, water, and sand for example.

DESCRIPTION: With the arrival of new body armor technology and the continuation of the Global War on Terrorism there are more survivors and an increase in the military amputee population.

The volume of an amputees residual limb changes throughout the course of a day and/or throughout the year. Additionally, moisture build up occurs inside the liner of a prosthetic socket Limb volume and shape changes and excess moisture can result from many different things: physical activity, thermo-regulation, heterotopic ossification, complex skin grafts, etc.

Such changes often make the interface between the socket and the residual limb inadequate, creating significant discomfort that can lead to the rejection of the prosthesis by the amputee.

Excess moisture can have a variety of effects on the residual limb. Excess moisture can cause skin irritation problems such as dermatitis and/or infection. Excessive moisture may cause a decrease in suspension of the prosthesis and or excessive pistoning of the limb within the socket, causing friction and skin irritation. When liners are worn prior to suture removal the liner may cause problems with the suture line. Additionally, the excess moisture and/or perspiration do contain bacteria which can cause skin irritation and/or infection if the liner is not cleaned appropriately.

Currently, moisture in the liner is managed by the patient regularly removing the liner and emptying the moisture, or at times, the patients are told to use some type of antiperspirant to decrease the volume of perspiration, or the patient simply does not wear the liner.

Finally, while some patients' sweat glands will decrease secreting perspiration, this condition is neither common nor consistent among all wearers.

Given recent advances in sensing devices, miniaturization, and materials and manufacturing technology, uncomfortable and/or non-performing sockets are unacceptable.

PHASE I:
1) Identify physiological response and adaptation to heat retention in elastomeric gel liners.
2) Plan and design a socket that senses and adapts in real time to changes in the residual limb.
3) Plan and design a socket/prosthesis interface that will maintain alignment during socket changes.
4) Plan and design a system that will isolate any resulting moisture/perspiration from the residual limb, and perform according the specific objective metrics.
5) Plan the design to utilize an energy source which allows the device to perform in a long lasting manner.

PHASE II: Develop and demonstrate a prototype accommodating socket and liner that senses and adapts, in real time, to changes in an exercising residual limb, maintaining necessary alignment, and conforming to all specific objective metrics under normal day-to-day conditions, as well as under conditions which might be encountered by deployed warfighters, or extreme athletes.

PHASE III: Move the prototype from the laboratory into production and the marketplace. Develop, provide and execute a training program that will support the proliferation of new devices to all appropriate patients. Program should address the unique needs of each of the following groups: prosthetic providers, ordering physicians, occupational and physical therapists, vocational counselors, and patients. Program may be on-site, virtual, or computer based - including didactic and hands-on modules that prepare the target population for maximizing the benefits of this technology in both vocational and avocational pursuits. Funding sources other than the SBIR will be sought and utilized for this commercialization. Provided the prosthesis meets phase I and phase II requirements, it may be utilized in DoD and VA facilities for military amputee patients as applicable.

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KEYWORDS: Socket-Limb Interface, Socket Liner, Socket, Liner, Dynamic, Sensing, Pro-active, Prosthetic Socket, Moisture Management, Perspiration, Residual Limb Health

OSD08-M01 TITLE: Assessment of Reballing Methods for Ball Grid Array (BGA) Devices

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To demonstrate the reliability of lead-free ball grid array (BGA) devices with respect to lead-free BGAs that have been reballed with a eutectic tin-lead (SnPb) alloy.

DESCRIPTION: The electronics industry is moving to lead-free electronics. While this has little impact on commodity consumer products, it has a large potential impact in applications where long service life and high

reliability are important. For high reliability applications that are currently exempt from the Restriction of Hazardous Substances Directive (RoHS), such as avionics and space, reballing of lead-free BGAs with SnPb solder balls is performed due to the increasing number of BGA suppliers switching to lead-free. This activity is being performed because suppliers of high-reliability electronics are concerned about the long-term reliability of lead-free materials, which have little to no demonstrated field performance. Nevertheless, reballing can be a poorly controlled process that can introduce life limiting defects into the BGA device.

The DoD needs a fundamental assessment of the reliability of reballed BGAs with respect to nominal lead-free and SnPb BGAs, as well as an assessment of the current industry standards on recommended reballing practices.

PHASE I: Develop a representative set of BGA devices and contract reballers for a round-robin study of the yield and associated metallurgical quality of reballed BGAs. Develop suitable test vehicles for reliability testing of these devices. Specify and purchase initial samples and perform preliminary testing over a range of conditions including thermal cycling, mechanical shock, and vibration. Exit criteria will consist of identification of key processing and metallurgical parameters, initial trends in relative performance, and a full-scale test plan

PHASE II: Execute the full-scale test plan developed in Phase I to extend testing to the full range of anticipated BGA packages, including various pitches (i.e., 0.5, 0.8, and 1.0 mm) and I/O (i.e., 64, 256, 1000). A more complete set of contract reballers should be used to address variations in reballing equipment and practices. Exit criteria will consist of a final report detailing an analysis of reliability performance as a function of reball processing, pitch, and application environment and a comparison to equivalent SnPb and lead-free BGAs. The report will include an algorithm that will identify a go/no-go decision point on reballing.

PHASE III DUAL-USE APPLICATIONS: Develop a software package to automate the analysis of reballing risks based on authorized vendor lists (AVLs) and the intended use environment. Private-sector commercial potential will be in the areas of electronics development, reliability design, analysis, and manufacturability.

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KEYWORDS: Keywords: solder, lead-free, tin whisker, ball grid array, thermal-mechanical fatigue, reliability

OSD08-M02 TITLE: Physics of Failure Based Electronics Reliability Analysis Software

TECHNOLOGY AREAS: Materials/Processes
OBJECTIVE: Develop physics of failure based algorithms into an Electronics Reliability Analysis Expert system to allow DoD to rapidly evaluate and compare new electronics modules to be used in highly stressing DoD environments.

DESCRIPTION: The ability to rapidly and accurately evaluate the reliability of electronics modules for use on DoD systems is important for decision makers from the design level up to the program manager. Current methods for providing reliability assessments include parts count methods such as MIL HDBK 217 and Telcordia TR-332. These methods of analysis are fast, but of little value due to the dependence on historical empirical data and generic parts types. The DoD needs a new approach to electronics reliability analysis that allows expert evaluation of presently available electronics and accurately represents the reliability of new designs and new generations of components. The desired system is an automated software package that can be used by a line engineer with little formal training in reliability to provide expert analysis. It should also be usable by a reliability expert to provide an additional level of precision. The software must be user friendly and allow rapid selection of the most common electronics and relevant DoD with an emphasis on harsh temperature and vibration environments. The software should be capable of being expanded as new technology is developed. The software must be based on Physics of Failure (PoF) to allow predictive capability for new technologies.

PHASE I: Develop the user interface and sufficient capability to analyze a simple printed circuit board assembly (PCBA) in a specified environment. Identify the physics of failure models for electronics and environments that are most relevant to DoD's needs. Exit criteria will consist of a demonstration of the user interface and available analysis tools.

PHASE II: Develop the models identified in Phase I into software algorithms and incorporate them into the software package. Perform a comparison between the software tool and a manual analysis. Exit criteria will consist of a software package capable of analyzing an electronics module in at least one DoD relevant environment.

PHASE III DUAL-USE APPLICATIONS: Extend the Electronics Reliability Analysis Expert system to all multiple DoD relevant environments and develop software modules to allow large scale systems analysis. Private-sector commercial potential will be in the areas of electronics development, reliability design, analysis, and manufacturability.

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KEYWORDS: Keywords: solder, lead-free, tin whisker, ball grid array, thermal-mechanical fatigue, reliability

OSD08-M03 TITLE: Assessment and Modeling of Shock and Vibration Performance of Lead-Free Alloys

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To demonstrate the performance of lead-free alloys in shock and vibration for a range of package types and develop physics of failure models analogous to those employed for eutectic tin-lead (SnPb) solders.

DESCRIPTION: The move to lead-free electronics in the commercial industry has introduced a wide array of solder compositions. Little is understood about the behavior of these new solders in harsh mechanical environments. Numerous lead-free alloys have been developed with a few particular alloy chemistries achieving predominance in surface mount (alloys SAC305, SAC105) and wave rework (alloy SN100C) soldering applications. The DoD needs a fundamental assessment of the performance of these alloys in shock and vibration conditions with respect to that of eutectic SnPb alloys and associated development or adaptation of physics of failure models to accurately predict performance in accelerated and nominal application environments.

To date, academic and/or industrial research have been limited in terms of the range of package types and solder joint geometries considered, as well as the range of lead-free alloys and the use of suitable SnPb controls. Furthermore, most studies have emphasized either low cycle (shock) or high cycle (vibration) fatigue, and do not clearly reveal anticipated transitions in behavior from plastic to elastic strain control. The desired evaluation will address the full range of package types (leaded, leadless, and area array devices) as well as the effects of lead pitch and board thickness.

PHASE I: Develop a suitable test vehicle for initial evaluation (one lead-free alloy and one package type) and perform analytical/numerical modeling of strain-displacement relationships during shock and vibration. Perform initial shock and vibration testing and analysis of results. Exit criteria will consist of a proposed preliminary model for prediction of shock and vibration performance and an associated test plan for validation.

PHASE II: Extend the testing performed in Phase I to address a range of package types (leadless, leaded, and area array), board thicknesses, and common lead-free alloys in a variety of shock and vibration environments. Exit criteria will consist of fully validated models and usage guidelines regarding limitations of particular alloys with respect to package types, board geometries, and application conditions.

PHASE III DUAL-USE APPLICATIONS: Extend the testing and analysis to multiple DoD application environments, and integrate the physics of failure models into existing software modules for lifetime prediction of complex electronic assemblies under cyclic mechanical load conditions. Private-sector commercial potential will be in the areas of electronics development, reliability design, analysis, and manufacturability.

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KEYWORDS: Keywords: solder, lead-free, tin whisker, ball grid array, thermal-mechanical fatigue, reliability

OSD08-M04 TITLE: Development and Validation of Tin-Whisker Growth Model and Accelerated Testing

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a tin whisker growth model and accelerated test that has been validated by application to real world environments and accelerates relevant growth modes.

DESCRIPTION: The Department of Defense is committed to the environmental health and safety (EH&S) aspects of the Reduction of Hazardous Substances (RoHS) efforts enacted by the European Union (EU). A key factor of RoHS that has impact to avionics reliability is the requirement to remove lead (Pb) from electronics. The use of pure tin (Sn) has the potential to cause tin whiskers to spontaneously erupt from the solder and cause electrical problems. Documented failures related to tin whiskers include aircraft electronics and satellite failures within the DoD as well as other long term applications in the civilian sector. A fundamental understanding of the mechanisms of tin whisker growth has not been developed fully, although significant progress has been made. To date, the industry research has focused on expedient solutions substantiated by tests applicable to niche environments. No consensus on accelerated testing to determine the risk of tin whiskers exists at this time. A systematic approach is needed that will first identify potential whisker growth mechanisms such as stress state, temperature, and other environmental or built in factors, perform a series of tests to determine the effect of each of these mechanisms, and generate a tin whisker growth model that unifies these factors. Once a growth model has been developed, it needs to be validated against other whisker growing systems. Finally, with a fully developed and validated whisker growth model, an accelerated test can be developed that represents actual use environments and excites whisker growth mechanisms. Knowledge of whisker growth mechanisms should allow a greater understanding of the reliability impacts of the many lead-free solders that are coming on the market.

PHASE I: Identify the primary drivers of whisker growth. Develop a test plan designed to generate the tin whisker growth model and perform preliminary experiments. Exit criteria will consist of a report detailing the relevant factors, a test plan, and a thorough description of how the test plan will address each whisker growth factor.

PHASE II: Execute the test plan and develop the whisker growth model. Use novel methodologies to validate the growth model. Develop and validate an accelerated test for whisker reliability. Exit criteria will consist of a test report showing the accelerated test. The test will be documented and proven on at least two applications. Sufficient numbers of samples will have been tested to provide statistically valid results.

PHASE III DUAL-USE APPLICATIONS: Develop and qualify an inexpensive tin whisker mitigation technique that is capable of rapid application using standard manufacturing practices. Private-sector potential will be in the areas of RoHS transitions in applications where high reliability and long service life are required, such as power distribution, and commercial satellites and aircraft.

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KEYWORDS: Keywords: solder, lead-free, tin whisker, ball grid array, thermal-mechanical fatigue, reliability